SURF AND SWASH ZONE HYDRODYNAMICS

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LONG-TERM GOAL

Improve understanding of the hydrodynamics of the near-shore motions on beaches, with particular reference to the zone where the incident waves have break, form surf, and run-up on the beach to give a fluctuating shoreline. This includes the waves and currents that the breaking waves, surf and run-up generate together with necessary details of the motions beneath the waves. Particular attention is directed to improving theoretical models of these motions.

SCIENTIFIC OBJECTIVES

The main topics for study are:
a) the turbulence generated by breaking waves and bores. A rational, non-empirical, approach to modelling unsteady spilling breakers and bores is a major target.
b) the modelling of surf in the presence of co-existing long waves.
c) improved, and perhaps simplified, modelling of the swash zone.
d) understanding the currents, eddies and long waves generated by the incident waves, especially for irregular non-uniform waves over non-uniform bed topography.

APPROACH

This grant is to enhance cooperation between the P.I.s and their respective groups in working towards the above goals. The duration of the grant has been chosen to encompass the whole active period of the Surf and Swash Zone Mechanics (SASME) project of the Marine Science and Technology (MAST 3) program of the European Commission. The P.I.s meet each other each year and their more junior associates can make extended visits to each other's institution.

In both groups the emphasis is on developing mathematical models through to practical numerical programs, with significant interaction with field and experimental results.

The start of the project has coincided with change in the post-doctoral personnel at Bristol. Dr.M.Brocchini has participated in some of the most significant developments on the swash zone and turbulence, by making fundamental studies of the averaging of unsteady and fragmented boundaries, e.g. Brocchini & Peregrine (1996). He is continuing in his cooperation from his new base at Genoa, Italy. In the near future significant input is expected from Dr.Ian Eames (arrived Bristol 1 Oct.1997 from Cambridge University), and Dr. Onno Bokhove (coming from Woods Hole Oceanographic Institution to Bristol for 1 Feb. 1998). Eames has expertise on mixing processes due to moving features: eddy couples are relevant to our flows,

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e.g. Eames & Flór (1997). Bokhove has expertise on vorticity dynamics in geophysical fluid dynamics, e.g. Bokhove (1997), and ocean/coastal interaction with both experimental and theoretical study.

At Delaware, one Ph.D. student has graduated and one will graduate at the end of 1997. Three Ph.D. students (one first year, one second year and one graduating within the next year or so) will then be working on topics related to the project. Additional funding for further student support is pending. Recent related publications are Veeramony & Svendsen (1996), Van Dongeren et al (1996), Svendsen et al (1996), Van Dongeren & Svendsen (1997), Haller et al (1997), Veeramony & Svendsen (1997), Putrevu & Svendsen (1997) (in addition to a number of papers presently under review).

WORK COMPLETED

In these first months of the project, Svendsen made a brief visit to Bristol, and Dr.M.Brocchini visited Delaware for five weeks. The former visit consolidated plans for this project. The latter visit covered a wide range of ground in detail. Particularly valuable discussions were held on the averaging of swash to form a realistic shoreline boundary condition for wave averaged models. Another topic with detailed discussions of mutual benefit was on turbulent flows generated at free surfaces, where the experimental measurements of turbulence in a hydraulic jump that are being made at Delaware formed a valuable source of data. The discussions included development of ideas and directions for work planned for the near future at both institutions and by Dr. M. Brocchini.

RESULTS

Interpretation of the mathematical expressions in Brocchini & Peregrine (1996) for modelling the swash zone was improved, but at the same time the (planned) need for more study and measurements was enhanced. Innovative velocity profile measurements in the swash are planned at University of Florence, Italy, under SASME, involving close collaboration with Peregrine and Brocchini.

The visit to Delaware has advanced preparation of a series of papers by Brocchini & Peregrine on the effects and modelling of strong turbulence at a free surface. The visit has also helped finalize the analysis by Veeramony and Svendsen of the hydraulic jump data and the similarity between the jump and the surf zone breaking waves. At present, two journal papers are planned for the publication of those results.

IMPACT/APPLICATION

In each of the four areas mentioned under OBJECTIVES major improvements in modelling are sought.

a) At present the best models for the surf zone include 'rollers' to model the breakers. The parameters describing these rollers are obtained from best fits to data. We aim to gain sufficient understanding of the hydrodynamic feedback between the foot and crest of a breaker that a more deterministic model that would include breaker initiation, merging and decay can be created.

b) It is well documented that the number of wave crests diminishes significantly through the surf zone. No available wave-averaged models include this feature, with its influence on the generation of long waves and currents. The planned work will benefit from earlier experiments at Delaware (Veeramony & Svendsen, 1996).

c) Almost all wave averaged models ignore the swash zone, simplifying it to a point of zero mean water depth and no velocity. This has stimulated the present work since the swash zone forms the land/sea boundary and is a place where the most active sediment motion tends to occur. Work to date is already leading the way to improved modelling of this vital zone.
d) Peregrine's (1995) disussion of the role of vortices and eddies in the surf zone has already brought a new view to surf zone dynamics. His recent (Peregrine, 1998) quantification of the changes of circulation and generation of vorticity by bores have the potential to give a new and simpler way of assessing currents from observation of the wave field. In addition they promise new insights into horizontal mixing and transport properties of the surf zone currents. [These excited considerable interest in the initial workshop of the SASME project.]

TRANSITIONS

Several of the twelve other groups in the SASME project will cooperate with Bristol. The intention being that contacts with experimental groups (e.g. at the Universities of Cantabria, Edinburgh, Florence, Plymouth and Cantabria) will include interaction on the best measurements for advancing theoretical studies and assistance in the interpretation of results. Similar interactions will occur with those running complex computer programs (e.g. International Centre for Computational Hydrodynamics at Danish Hydraulic Institute [ICCH], and Delft Hydraulics).

Interactions will occur between Delaware and the groups conducting hydrodynamic field experiments at Duck, North Carolina (Scripps, Naval Postgraduate School, Oregon State University and others). Close interaction will continue between Delaware and the researchers at NorthWest Research Associates (Putrevu, Oltman-Shay) and with the ICCH in Denmark.

RELATED PROJECTS

At Bristol, in addition to the SASME project Peregrine also has:

1) A project funded by the U.K.'s Defence Evaluation and Research Agency (DERA), including Reading University, to study the effects of surface currents on the patterns and breaking of surface waves with reference to remote sensing. This is closely related to experimental work DERA is participating in at University of California Santa Barbara, Ocean Engineering Laboratory with radar and water waves. It helps this grant's area of study by giving a different view on the modelling of breakers, and is substantially increasing expertise on wave-current interactions.
2) Another MAST 3 project: Probabalistic Design of Vertical Breakwaters (PROVERBS). Aspects of this project relating to porous berms and foundations provide valuable insights for studying porous beaches. The significant advances we are making in modelling violent impacts have wide application. A further project on impacts between waves and the base of structures such as decks, funded by the U.K. Engineering and Physical Sciences Research Council is due to start in early 1998.
3) A research student funded by the U.K. Natural Environment Research Council (NERC) is commencing study of waves over porous beaches with emphasis on coarse sediment where the porous flow is at high Reynolds number. This is an area where we have identified points for study from PROVERBS experiments and models for breakwaters, and similar experiments on breakwaters in Bristol University's Hydraulics Laboratory. Any results may apply equally apply to beaches and breakwaters.
4) A research student funded by Portugal's Research Funding Council is studying the effect on edge waves of strong changes in otherwise uniform coasts. This and other recent work in Bristol's Mathematics Department (Fernyhough & Evans, 1995) is extending our understanding of the propagation of low frequency waves along coasts.

Related projects at Delaware include an ONR funded project for collecting additional field data (waves & currents) at Sandy Duck to enhance modelling capabilities, in particular with respect to nearshore circulation, and the generation and propagation of infragravity waves.

Laboratory and numerical modelling of rip currents on barred beaches have been the subject of an ONR funded project with two graduate students involved. An extension of this project aiming at studying the 3D effects of rip currents with one graduate student is presently funded by Sea Grant, and funding for further research in this area will be sought soon.

Funding is pending for planned work on modelling and analysis of the new Sandy Duck data and so is funding for work on developing an effective Boussinesq wave driver for nearshore circulation models. The latter of these two projects will be closely connected to the present NICOP project, and will also benefit from close contact with ICCH, and the remote sensing project at Delaware (Kirby, Dalrymple).

REFERENCES

Bokhove, O. (1997)Slaving principles, balanced dynamics and the Boussinesq equations. *J.Atmos. Sci.* **54**, 1662-1674.

Brocchini, M. & Peregrine, D.H., (1996) Integral flow properties of the swash zone and averaging, *J. Fluid Mech.* **317**, pp.241-273.

Eames, I & Flór, J.-B. (1997) Fluid transport by dipolar vortices, preprint.

Evans, D.V. & Fernyhough, M. (1995) Edge waves along periodic coastlines. Part 2, *J.Fluid Mech.* **297**, , 307 - 325

Haller, M.C., Dalrymple, R.A. & Svendsen, I.A. (1997). Rip channels and nearshore circulation: Experiments. *Proc. Coastal Dynamics '97*, Plymouth, UK (in press).

Peregrine, D.H. (1995) Vorticity and eddies in the surf zone, *Proc. Coastal Dynamics* '95, ASCE. Gydnia, 460-464.

Peregrine, D.H. (1998) Surf zone currents. *Theor. & Computational Fluid Dynamics* to appear.

Svensdsen, I.A., Veeramony, J. & Yu, K. (1996). A Boussinesq breaking wave model with vorticity. *Proc. 25th Intl. Conf. Coastal Engrg.*, ASCE, Orlando 1192-1204.

Van Dongeren, A.R., Svendsen, I.A. & Sancho, F.E. (1996). Generation of infragravity waves. *Proc. 25th Intl. Conf. Coastal Engrg.* ASCE, Orlando 1335-

Veeramony, J. & Svendsen, I.A. (1996). Wave groups in the surf zone: Model & experiments. *Proc. 25th Intl. Conf. Coastal Engrg.* ASCE, Orlando, 151-164

Van Dongeren, A.R. & Svendsen, I.A. (1997). An absorbing-generating boundary condition for shallow models. *J. Waterway, Port, Coastal and Ocean Engineering*, ASCE, **123**, 6, 303-314. .

WORLD WIDE WEB PAGES

http://www.maths.bris.ac.uk/~madhp
Peregrine's home page, with access to full publication list.

http://www.coastal.udel.edu/~svendsen
Svendsen's home page, with access to full publication list.

http ://www.wldelft.nl/sasme/sasme.htm
The home page of the SASME project.